ESTIMATING PRICE AND SERVICE ELASTICITY OF URBAN TRANSPORTATION DEMAND WITH STATED PREFERENCE TECHNIQUE: A CASE IN KOREA

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Abstract— In this research paper, price and service elasticities of passenger car travel are estimated using stated preference (SP) and sample enumeration methodology. Moreover, the effects of hypothetical TDM policies are analyzed in terms of changes on modal share utilizing the elasticity estimates. The elasticity of passenger car travel with respect to fuel price is estimated to be within the -0.078 to -0.171 range. The parameter estimate of the fare variable is estimated to be statistically insignificant in every sub-group of car users. This finding suggests that fare policies are relatively ineffective for increasing transit modal shares in Korea. Meanwhile, car user's responsiveness to changes in parking costs is estimated to be much higher than fuel cost. This suggests that parking regulations or pricing policies may be effective in reducing travel by passenger car. The elasticity with respect to in-vehicle time, which is a key attribute of public transport amenities, is estimated to be particularly high, implying that policy measures such as introducing express buses or express urban trains could be effective in reducing passenger car travel. The demand elasticity of service levels of mass transit represented by the degree of crowdedness proxy turns out to be very high. Reducing crowdedness in public transit can be very effective in attracting more passengers, or at least retaining current patronage.

Keywords: Stated preference, price elasticity, service elasticity, urban transportation demand, TDM

1. INTRODUCTION

Information on the elasticity of urban transport demand with respect to price or service level is very important in quantitatively analyzing the effects of urban travel demand management (TDM) policies. However, there has been little research done in the area of elasticities of demand for car use nor in the area of public transport in Korea so far. In this sense, quantitative evaluation of TDM policies has been greatly restrained in the Korean context.

In this research paper, price and service elasticities of passenger car travel in the Seoul Metropolitan area are estimated using stated preference (SP) and sample enumeration methodology. The purpose of this research is to provide information on the effectiveness of policy measures to reduce demand for urban travel in private automobiles. In addition to the traditional price elasticity estimation, we also estimate the elasticity with respect to the service or amenity levels. Service levels are represented by the travel time and the level of comfort approximated by the crowdedness index. The findings from this study can be used in identifying more effective policy measures and thus in aiding the policy makers to make a more informed choice in urban TDM. Although the results of this study can be interpreted in the Seoul context, the analytical framework of this study can be applied in other cities with the proper modifications in survey design.

The discrete choice model, which analyzes effectiveness of each explanatory variable and uses socioeconomic characteristics and transportation decision-making data of individuals on mode choice, is divided into RP (Revealed Preference) model and SP model depending on the data. While the RP model is the methodology of estimating demand behavior based on the data of individuals who have automobiles currently, the SP model is the estimation methodology based on survey data about individuals' choice behavior in a theoretical situation. The SP technique is widely used and methodological limitations have been reduced. As such it is perceived to be useful for analyzing the effectiveness of newly developed policies despite some analytical limitations. Specifically, a great advantage of the SP technique is that it is possible to estimate arc elasticity over a wide range of price levels rather than point elasticity. The former can be regarded as more useful than the latter in policy analysis because demand elasticity of transportation normally differs with different price levels.

2. LITERATURE REVIEW AND COMPARISON WITH OTHER RESEARCHES

Although there has been little research on fuel price elasticity of demand for car use in Korea, there are various results of research on price elasticity of fuel consumption. As they fall into the range of -0.092 and -0.54 (Lee et al, 1998), there are big differences among them in Korea according to the research methodology and data.

Most urban transport demands are shown to be inelastic to prices in the range of -0.20~-1.10, as seen in Table 1. In particular, the long run elasticities tend to be more than twice as big as the short run elasticities.

Table 1. Elasticities of Demand for Urban Transportation

Demand	Attributes	Elasticities		
		Short run	Long run	Overall
Fuel consumption	Fuel price	-0.27	-0.73	-0.48
Car use	Fuel price	-0.33	-0.30	-0.39
Car ownership	Fuel price	*	*	-0.21
Car ownership	Car price	*	*	-0.87
Traffic	Toll fee	*	*	-0.45
Demand for bus	Bus fare	-0.30	-0.65	-0.41
Demand for subway	Subway fare	-0.20	-0.40	-0.20
Demand for rail	Railway fare	-0.70	-1.10	-0.65
Mass transit	Fuel price	*	*	+0.34
Car ownership	Transit fare	*	*	+0.10

Note: Short run means usually within a year, and long run means 5 to 10 years.
Source: UK Department of Transport

According to Goodwin (1992), fuel price elasticity of demand for fuel consumption was found to be between -0.2~-0.8. As in Table 1, the long run elasticities are three times as high as the short run elasticities, as shown in Table 2. The long run elasticities are bigger due to the long length of time it takes for consumers to adjust their transport demands in a profound way, such as the purchase of smaller cars, moving residence, and changing frequencies.

Table 2. Price Elasticity of Demand for Fuel Consumption

	Short run	Long run	Overall
Time-series	-0.27	-0.71	-0.53
Cross-section	-0.28	-0.84	-0.18

Source: Goodwin (1992)

Table 3 shows fuel price elasticity of demand for car use. Although fuel price elasticity of demand for car use is not expected to be very different from that for fuel consumption in the short run, the former may be smaller than the latter in the long run. This can be explained by consumers, while keeping their basic demand for transportation constant, tending to save on their overall energy costs by downsizing their cars and increasing efficiency when long term fuel prices increase.

Table 3. Fuel Price Elasticity of Demand for Car Use

	Short run	Long run	Overall
Time-series	-0.16	-0.33	-0.46
Cross-section	*	-0.84	-0.18

Source: Goodwin (1992)

3. SP SURVEY AND ESTIMATION RESULTS

3.1. Designing SP Survey and Estimating Models

In the SP survey, individuals are required to answer a choice between two alternatives. In the transportation mode choice, the supply-side variables used are travel time, travel expense, service levels of congestion and service levels of headway. Demand side variables are generally composed of income, sex, and education. In cases where these variables are too numerous, and the levels of variables too widely varied in order to be able to identify trade-off of modal choices, it is practically impossible to create a full factorial design which includes all the possible sets of SP questionnaires. Therefore, a fractional factorial plan, which analyzes only the main, most important effects and guarantees the orthogonality of variables, is generally applied in the SP technique (Hensher, 1994).

In estimating demand elasticities of mode choice behavior, individuals are first asked to choose the alternative mode, and then apply an SP analysis only on the alternative mode chosen. This simplifies the complexity of the SP questionnaires and allows individuals to express their true preferences and, thus, the trade-off between the explanatory factors without confusion. The SP design of mode choice between passenger cars and alternative modes of bus usage and subway usage in urban transportation is described in Table 4, where the explanatory variables are travel expense, travel time, and service level. In Table 1, the purpose of the SP Design is to analyze the main effects by using a fractional factorial plan with orthogonality between variables. For an SP design guaranteeing orthogonality, each explanatory variable is set up in three different levels, and the questionnaires are constructed following the experimental design and theoretical model of Kocur et al. (1982).

Table 4. SP Design of Mode Choice between the Alternative Modes

Modes	**Explanatory variables**	**# of levels**	**Levels**		
			Level 1	Level 2	Level 3
Basic mode (private automobile)	Fuel price	3	Current level (about 1,200 won per liter)	Increase to 1,500 won per liter	Increase to 1,800 won per liter
	In-vehicle time	3	Current level	20% higher	40% higher
	Monthly parking fee	3	Current level (about 150,000 won)	40,000 won higher	80,000 won higher
Alternative mode (bus and subway)	fare	3	400 won lower	200 won lower	Current level (500-1,000 won)
	In-vehicle time	3	40% lower	20% lower	Current level
	Out-vehicle time	3	50% lower	25% lower	Current level
	Congestion (comfortableness)	3	No congestion	Medium congestion	High congestion

Note: US $ 1.00 is equivalent to 1,210 Korean Won as of Nov 14, 2002.

Therefore, based on the above SP design, the utility functions of the original mode and alternative modes for estimating logit model are as follows;

$$U_{oricar} = \alpha + \beta_1 \cdot Fuel + \beta_3 \cdot Ivt + \beta_5 \cdot Park$$

$$U_{altmode} = \beta_2 \cdot Fare + \beta_3 \cdot Ivt + \beta_4 \cdot Ovt + \beta_6 \cdot Crowd$$

where *altmode = bus, subway, bus+subway*

(*oricar*: original mode of passenger car, *altmode*: alternative mode, *bus*: bus, *sub*: subway, *bus+subway*: dual use of bus and subway, *Fuel*: fuel price, *Fare*: fare of bus or subway, *Ivt*: in-vehicle time, *Ovt*: out-vehicle time, i.e., interval accessing bus and access time in the subway, *Park*: parking fee, *Crowd*: crowdedness, i.e., comfortableness as a service measure)

In this study, well-trained interviewers performed the survey on 662 people using passenger cars in Seoul Metropolitan Area during 23-30 November 1999. As seen in Table 5, the main purpose of using passenger cars is for commuting (71.5%) and business trips (16.4%).

Table 5. Trip Purpose of Passenger Car Users

	commuting	business	shopping	leisure	attending school	others	total
# of people	445	102	13	24	22	16	622
Share(%)	71.5	16.4	2.1	3.9	3.5	2.6	100.0

After the interviewees were asked about their alternative transport mode, they answered the questionnaires with the changing level of attributes for the choice between car and their alternative mode chosen. On the survey data of binary choice, a logit model was applied. We take the first step of the pretest to identify their choice on alternative modes, rather than using a multiple logit model, in order to ensure accuracy of interviewee response. The multiple choice model creates too big a burden on the interviewees' capability to answer correctly for multiple levels of attributes in SP questionnaires. In fact, the binary choice model seems to be widely accepted as being the most practical and easily applicable method in recent research with the SP technique (Steer Davies Gleave, 1996). In order to analyze the independent choice behavior between car and bus, between car and subway, and between car and bus+subway, an independent model was constructed for each of the three sets to create three different models in total. For estimating these binary logit models, the Discrete Choice Model from the LIMDEP package was used.
Although in total 27 scenarios of questionnaires can be constructed with 3 levels of explanatory variables, each interviewee is asked to answer for just 9 scenarios chosen at random. After deleting inconsistent data using the suitability test, we confirmed 4,228 effective data sets.

3.2. Estimation Results

As can be seen in the estimation results in Table 6, the coefficients of travel expense and travel time have a negative value corresponding to the theory of mode choice behavior. Although most of the variables appeared to be statistically significant with a high t-value, the fare variable of mass transit was statistically insignificant (low t-value). This may be due to car users not considering the fare level of mass transit as significant, since the fare is significantly smaller than the user expense of a car. As the ρ^2 (Rho square) of likelihood ratio index is close to 0.2, all of the models are considered to be acceptable.

Table 6. Estimation Results of Mode Choice Behavior of Car Users

Variables	car → bus		Car → bus+subway		car → subway	
	coefficient	t-value	coefficient	t-value	coefficient	t-value
Car dummy	1.6362	5.505	0.99752	5.207	0.50605	2.29
Fuel price	-1.01E-04	-3.067	-1.17E-04	-5.241	-6.10E-05	-2.848
Fare of bus or subway	-2.00E-04	-1.456	-1.41E-04	-2.862	-5.40E-05	-0.637
In-vehicle time	-4.21E-02	-8.106	-2.76E-02	-9.376	-3.80E-02	-10.717
Out-vehicle time	-4.41E-02	-3.486	-2.81E-02	-5.053	-6.49E-02	-7.089
Parking fee	-3.63E-04	-6.36	-2.49E-04	-6.188	-2.61E-04	-6.018
Crowdedness	0.83081	8.38	0.64431	9.306	0.58023	7.508
ρ^2 (Rho square)	0.19		0.20		0.22	
No. of responses	943		1,783		1,502	

The positive value associated with the car dummy in the three models shows that car users prefer car travel than various forms of mass transit. Even though the absolute value of the estimated coefficient of fuel is somewhat smaller than that of fares, the demand elasticity of fuel price is expected to be much higher than that of the fare level, since, for car users, the fuel expense is far more significant than the fare. But, as the absolute value of the estimated coefficient of fares compared to fuel in the model of car → bus is bigger than that in the model of car → subway, car users are shown to respond to bus fare changes more so than subway fare changes.

As the absolute value of the estimated coefficient of out-vehicle time is bigger than that of in-vehicle time, the absolute levels of the coefficients are about the same except in the case of car → subway. The bigger out-vehicle time implies bigger subjective disutility associated with waiting. In case of Seoul, mass transit, especially city buses are very crowded and the disutility associated with riding public transport in Seoul may be far greater than that of other cities in developed countries. This may imply that mass transit riders in Seoul dislike riding buses as much as waiting for the bus to come and this would provide some explanations for the deviation from the other city cases.

Car users appeared to be very sensitive to parking fees, since the estimated coefficient of parking fees is more than two times bigger than that of fuel prices. This implies that the perceived cost of parking is much greater than fuelling. This also implies the greater potential of parking policy rather than fuel pricing in TDM.

While crowdedness as a service measure is shown to be an important factor for car use, car users seem to consider bus crowdedness more significant than subway crowdedness.

In the case of car → bus, car users are more sensitive to in-vehicle time and crowdedness than in the other cases. This implies that car users could become bus users by improving the quality of bus service and by shortening the travel time of buses through the introduction of HOV lanes.

4. PRICE ELASTICITIES OF DEMAND FOR URBAN TRANSPORTATION AND POLICY EFFECT

4.1. Fuel Price Elasticities and Modal Share

Using the estimated coefficients of the models, price elasticities were estimated through a Sample Enumeration method. Sample enumeration is the method in which the demand change for a car is calculated before and after a price change, using an individual's choice probability between a car and the alternative modes obtained from estimated models and an individual's data. This method has the advantage of allowing us to estimate arc elasticity rather than point elasticity, which has different values with each different price change (Steer Davies Gleave, 1996).

As seen in Table 7, fuel price elasticities of demand for passenger car use are estimated to be in the inelastic level of -0.078 to -0.171. Among them, the elasticity in the case of 'car-subway' is the lowest, and the elasticity in the case of 'car-bus+subway' is the highest. Therefore, with a 50% increase in fuel price, we expect that the modal share could move from passenger cars to alternative transit modes of bus and/or subway at the level of minimum 3.9% to maximum 8.5%.

Compared to the single users of bus or subway, the predominant reason why the dual users of bus and subway show higher fuel price elasticities is essentially due to the relatively longer commuting distance they have, which, with the amount of fuel expense involved, leads them to react more significantly.

Table 7. Fuel Price Elasticities of Demand for Car Use and Change of Modal Share

		Fuel Price Elasticities	**Change of Modal Share from car to transit modes (%)**
Car-bus	10% price increase	-0.086	0.86
	20% ”	-0.086	1.72
	30% ”	-0.086	2.59
	40% ”	-0.086	3.45
	50% ”	-0.086	4.32
Car-subway	10% ”	-0.078	0.78
	20% ”	-0.078	1.55
	30% ”	-0.078	2.33
	40% ”	-0.078	3.11
	50% ”	-0.078	3.88
Car-bus+subway	10% ”	-0.171	1.71
	20% ”	-0.171	3.41
	30% ”	-0.171	5.11
	40% ”	-0.171	6.79
	50% ”	-0.169	8.47

4.2. Fare Elasticities and Modal Share

The subsidy on the fares of transit mode is an important policy to reduce passenger car use and congestion in urban transportation. This policy has been widely used in various countries including the US, Japan, Canada, and European countries. In this study, when we included fare level of transit mode as an explanatory variable in the model, the estimation results show that it is statistically significant only in the model of ‘car-bus+subway’. The reason why the estimates of fare in single use are statistically insignificant is because the fare level of transit mode in Korea is significantly lower than other countries. For instance, a 50% increase from the current level of standard fares in Korea corresponds to an amount of only 250 won (about US $ 0.21). The reason why it is significant only in dual usage is due to fares being at least twice that of single mode, since there is no free transit or transfer among transit modes in Korea.

The cross price elasticity of demand for passenger car use was estimated through sample enumeration technique. As seen in Table 8, the estimates have the range of minimal level from 0.016 in ‘car-subway’ to 0.087 in ‘car-bus+subway’. The corresponding change of modal share from car to mass transit with a 50% fare decrease is 4.35% at most. Therefore, we can conclude that the policy of subsidizing transit fare is not expected to decrease car use significantly in Seoul.

Table 8. Fare Elasticities of Demand for Car Use and Change of Modal Share

		Fare (cross price) elasticity	Change of Modal Share from car to transit modes (%)
Car-bus	10% fare decrease	0.058	0.58
	20% ”	0.058	1.16
	30% ”	0.058	1.75
	40% ”	0.058	2.33
	50% ”	0.058	2.92
Car-subway	10% ”	0.016	0.16
	20% ”	0.016	0.33
	30% ”	0.016	0.49
	40% ”	0.016	0.66
	50% ”	0.016	0.82
Car-bus+subway	10% ”	0.086	0.86
	20% ”	0.086	1.73
	30% ”	0.087	2.60
	40% ”	0.087	3.47
	50% ”	0.087	4.35

4.3. Asymptotic t Test on the Effect of Parking Fees and Modal Share

It has been asserted that car use is usually more sensitive to parking fees than to fuel price (Button, 1993). This is based on the theory that, with the same level of fuel price and parking fee, car users perceive the costs in a different way. That is, car users generally consciously perceive parking costs more so than fuel costs.

In order to test the difference in the explanatory power of variables due to the difference in perceived costs, we implemented the Asymptotic t Test. For testing the null hypothesis that the estimates of the coefficients of fuel price and parking fees are the same, we need the test statistic of the following.

$$\frac{\hat{\beta}_i - \hat{\beta}_j}{\sqrt{\mathrm{var}\left(\hat{\beta}_i - \hat{\beta}_j\right)}}$$

The result of the Asymptotic t Test is summarized in Table 9. In all models the null hypothesis was rejected at the 5% significance level. This means that the parking fee holds more power for affecting car usage than does fuel price, and thus a policy of changing parking fees is more effective than the policy of changing fuel price in urban transportation demand management.

Table 9. Results of Asymptotic t Test for Indifference between Variables

Modes	**Asymptotic t Test Statistic**	**Results**
Car-bus	4.08	Reject null
Car-subway	4.22	Reject null
Car-bus+subway	2.95	Reject null

In Table 10, the rate of change of modal share is shown when parking fees were increased by 40,000 won (approximately US $33.00) and 80,000 won (US $ 66.00) a month. With the increase of 40,000 won, car use is expected to decrease by approximately 13~15%, while with the 80,000 won increase of parking fees the reduction rate will increase to 25~30%. However, since each current individual level of parking fee is not the same, the cross price elasticity of parking fee cannot be estimated.

The majority of the respondents (65.4%) pay less than 10,000 won (US $ 8.26) per month for parking. This is because most of the employee parking is still provided free of charge or heavily subsidized in most companies in Korea. The fueling cost turned out to be substantially higher. Majority of the respondents fall into the category of 100,000 ~ 150,000 won (US $ 83 ~ 124) per month. About 21% of the respondents answered that they spend more than 250,000 won (US $ 206) per month for fuel. Therefore, the concept of paid parking at work is still foreign to many car commuters in Seoul and their reaction to it seems to be greater than reaction to fuel price hike.

Table 10. Change of Modal Share due to Increasing Parking Fee

			Modal share before and after the change of parking fee	Change of modal share (%)
+40,000 won per month	Car-bus	Car	0.660 → 0.562	-15
		Bus	0.340 → 0.438	29
	Car-subway	Car	0.576 → 0.502	-13
		Subway	0.424 → 0.498	18
	Car-bus+subway	Car	0.567 → 0.495	-13
		Bus+subway	0.433 → 0.505	17
+80,000 won per month	Car-bus	Car	0.660 → 0.460	-30
		Bus	0.340 → 0.540	59
	Car-subway	Car	0.576 → 0.428	-26
		Subway	0.424 → 0.572	35
	Car-bus+subway	Car	0.567 → 0.423	-25
		Bus+subway	0.433 → 0.577	33

5. TIME ELASTICITIES, RESPONSE TO SERVICE VARIABLE, AND POLICY EFFECTS

5.1. In-vehicle Time Elasticities and Modal Share

The cross elasticity of in-vehicle time of transit for the demand of car use was estimated by using the sample enumeration technique. As seen in Table 11, when in-vehicle time of transit decreases by 10~50%, the cross elasticity of demand for car use ranges between 0.46 and 0.57. In particular, the in-vehicle time elasticity, which is the cross transit time elasticity of demand for car use, is largest in the model of the car-subway. As we have seen in Table 8, 29% of car users will use the subway, if the speed of subway improves two folds. Therefore, it implies that the introduction of an express subway transit system may be an effective policy for reducing car use and traffic congestion in Korea. In the case of buses, the policy of enhancing transit speed through implementing express buses in the Seoul metropolitan area is expected to be effective in reducing congestion, too.

Table 11. In-vehicle Time Elasticities of Demand for Car Use and Modal Share

		In-vehicle (cross) time elasticity of demand for car use	Change of modal share from car to transit modes (%)
Car-bus	10% decrease	0.459	4.59
	20% ”	0.471	9.42
	30% ”	0.481	14.43
	40% ”	0.489	19.57
	50% ”	0.495	24.77
Car-subway	10% ”	0.549	5.49
	20% ”	0.559	11.18
	30% ”	0.567	17.01
	40% ”	0.572	22.89
	50% ”	0.575	28.73
Car-bus+subway	10% ”	0.512	5.12
	20% ”	0.517	10.35
	30% ”	0.520	15.61
	40% ”	0.521	20.84
	50% ”	0.520	25.99

5.2. Out-vehicle Time Elasticities and Modal Share

Even when the absolute value of the estimated coefficient of out-vehicle time was bigger than that of in-vehicle time as in Table 6, the cross elasticity of out-vehicle time of transit for the demand of car use was estimated to be smaller than that of in-vehicle time when using a sample enumeration technique. As seen in Table 12, when out-vehicle time of transit decreases by 10~50%, cross elasticity of demand for car use is between 0.19 in the case of car-bus and 0.38 in the case of car-subway. This implies that the policy of increasing the frequency of buses and the subway is also very effective for promoting the use of transit modes and thus reducing traffic congestion in Korea.

Table 12. Out-vehicle Time Elasticities of Demand for Car Use and Modal Share

		Out-vehicle (cross) time elasticity of demand for car use	Change of modal share from car to transit modes (%)
Car-bus	10% decrease	0.197	1.97
	20% ”	0.200	3.99
	30% ”	0.202	6.05
	40% ”	0.204	8.15
	50% ”	0.206	10.28
Car-subway	10% ”	0.364	3.64
	20% ”	0.369	7.38
	30% ”	0.373	11.20
	40% ”	0.377	15.08
	50% ”	0.380	18.99
Car-bus+subway	10% ”	0.208	2.08
	20% ”	0.210	4.19
	30% ”	0.211	6.33
	40% ”	0.212	8.48
	50% ”	0.213	10.65

5.3. Response to Service Variable of Congestion

In this study, the level of service in transit modes is defined as the level of crowdedness in vehicles. Using estimated coefficients and the sample enumeration technique, the change of modal share was estimated corresponding to improving or worsening the congestion by one step among the three levels of congestion, as in Table 13. If the congestion of transit modes decreases one step, car users are expected to transfer to alternative modes by a value of 18~25%. This implies that improving in-vehicle congestion as well as improving on the travel time of transit modes is very important for promoting the use of transit modes and reducing traffic congestion in Korean urban transport.

Table 13. Car Users' Response to Service Variable of In-vehicle Congestion

		Change of modal share
Car-bus	Improving one step	25.05 % from car to bus
	Worsening one step	21.92 % from bus to car
Car-subway	Improving one step	17.85 % from car to subway
	Worsening one step	17.47 % from subway to car
Car-bus+subway	Improving one step	20.71 % from car to bus+subway
	Worsening one step	20.46 % from bus+subway to car

6. CONCLUSION

As there has been little research done on price and time elasticities of demand for car use in Korea, no one has been sure of the actual effectiveness of any policy proposals on TDM. In this research, price and service elasticities of passenger car travel in Seoul Metropolitan area of Korea were estimated using stated preference (SP) and sample enumeration methodology. Moreover, the effects of hypothetical TDM policies were analyzed in terms of changes on modal share utilizing the elasticity estimates.

The elasticity of passenger car travel with respect to fuel price was estimated to be within -0.078 to -0.171 range. The parameter estimate of fare variables was estimated to be statistically insignificant in every sub-group of car users. This finding suggests that fare policies are relatively ineffective for increasing transit modal shares. Meanwhile, the car user's responsiveness to changes in parking costs was estimated to be much higher than fuel costs. This suggests that parking regulation or pricing policies may be effective in reducing travel by passenger car.

The cross elasticity of passenger car travel with respect to travel time of mass transit was analyzed in terms of out-of-vehicle time and in-vehicle time. The elasticity with respect to in-vehicle time was estimated to be particularly high, implying that policy measures such as introducing express buses or express urban trains could be effective in reducing transit travel time and ultimately in reducing passenger car travel. The cross elasticity of passenger car use with respect to service levels of mass transit was also estimated, and it turned out to be very high. Measures to reduce crowdedness in transit could be effective in attracting more passengers, or at least retaining current patronage.

This research provides information on the effectiveness of various TDM measures in the Korean context. Thus the results reflect socio-economic as well as the transportation related conditions of the city that were analyzed. It would be very interesting if we could analyze other Korean cities with different transportation related characteristics. The transit fare elasticity is estimated to be very low in this analysis. However, the effect of complete transit fare subsidy needs to be analyzed in the future since the elasticity might show different magnitude in the very high levels of price or fare changes.

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